The Runway Overrun Prevention System

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1 | Introduction

Airbus has developed the Runway Overrun Prevention System (ROPS) as a response to runway overrun events during the landing phase. The ROPS is presently being certified for the A380, under a new specific EASA performance regulation, in conjunction with the Brake To Vacate system.

Runway excursions during the landing phase now represent the largest category of accidents in air transport, amounting to approximately 20 percent of all reported occurrences.

This article will describe how the system:

- Keeps the pilots informed during approach, through its intuitive interface, so that they can better make the necessary decision on whether or not to go-around
- Assists and warns the crew after touch down on the necessary actions to reduce the risk of runway overruns, or to limit the overrun speed.

2 | Main contributing factors

There are many contributing factors to runway overruns during the landing phase.

One of the major contributors has been and remains, unstable approach, to which the industry has responded by emphasizing training and procedures.
In an unstable condition, without actual information on the risk of a consequent runway overrun, the crew may be tempted to continue an approach in the belief that they may recover the situation, or that they have sufficient landing distance margins.

Other identified factors contributing to overruns at landing are:

- Wind shift at low altitude
- Long flare
- Long de-rotation
- Late selection of engine thrust reversers
- Cancellation of reversers at 70 knots
- Runway friction coefficient lower than expected (contaminated runway, snow, ice or runway more slippery than reported)
- Late/weak manual braking
- Technical failures affecting the landing distances during the landing (tyre burst, braking system failure…).

Following in-service experience, the Certification Authorities have recognized the need to create new regulations for the in-flight computation of the Landing Distances published in the Airplane Flight Manuals.

This led to the creation of the Take-off and Landing Performance Assessment Aviation Rulemaking Committee (TALPA ARC), an industry group, in which regulators, airlines, airport operators, associations and manufacturers, including Airbus, were represented.

The Committee has now finalized its proposal for new regulation for in-flight landing distance assessment.

The ROPS computation algorithms are already consistent with these proposed regulation changes.

The content of these new proposals will be detailed in an article included in the next release of Safety First (issue #9) in January 2010.

From BTV to ROPS

The ROPS represents a development of the Airbus Brake-to-Vacate (BTV) system.

During the approach preparation, the BTV automatically displays the landing distance that can be reasonably achieved, under normal operating conditions, on the selected landing runway.
This landing distance is based on predicted data. If that runway's Landing Distance Available (LDA) is lower than the displayed landing distance, initiating an approach is not advised, and a change of runway or diversion should be considered.

The automatic display of the operational landing distance allows the crew to select, during the landing preparation, a desired runway exit.
An exit that provides an available landing distance shorter than the displayed landing distance achievable on a dry runway cannot be selected, as it would not be achievable in normal conditions.

During the landing roll, the BTV ensures that the aircraft is decelerated to taxi speed, when the requested exit is reached, while optimizing the deceleration profile.

The main advantages of this system reside in an increase in passenger comfort, combined with a reduction of brake wear and temperature, thrust reversers usage and runway occupancy time.

For a detailed description of the BTV, please refer to the July 2009 issue of the Airbus FAST magazine.

Airbus decided to use the BTV as the basis for the development of safety functions intended for the prevention of runway excursions
The ROPS was born.

3 Description of the ROPS

The ROPS assists the flight crew, during the approach and roll-out, in preventing runway overruns.

The system integrates two functions:

- A warning function, called Runway Overrun Warning (ROW), which applies in flight and is go-around oriented.
- An active protection function, referred to as Runway Overrun Protection (ROP), which applies on ground and is stop oriented.

The following description assumes that the ROPS is working in BTV mode, as it allows the operation of all available system functionalities.

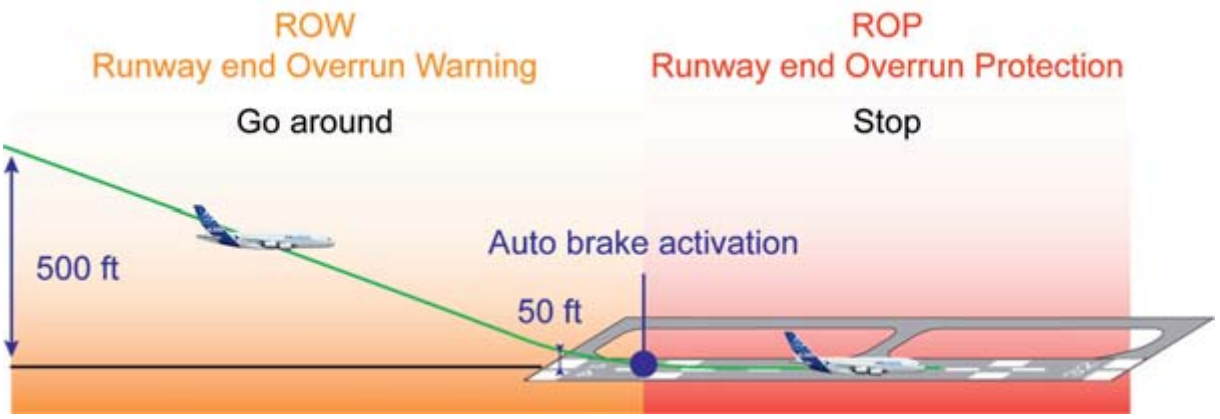

Figure 1: ROW/ROP functions

Note: On the A380, if Ground Spoilers are extended, Auto-Brake activation of the braking corresponds to the Nose Landing Gear touchdown, or 5 seconds after Main Landing Gear touchdown, whichever comes first. If thrust reversers are selected at touch-down, go-around is no more an option, and therefore ROW alerts are inhibited.

3.1 The Runway Overrun Warning

From 500ft Radio Altitude (RA) until Auto-Brake activation, the Runway Overrun Warning (ROW):

- Computes and displays predicted DRY and WET lines on the Navigation Display (ND)
- Triggers alerts in case of predicted runway overrun conditions.

3.1.1 ROW: The DRY and WET lines on the ND

The DRY line provides a landing distance that can be reasonably achieved, under normal operating conditions, on a dry runway. This distance assumes:

- A realistic manual or automatic landing, normal flare and de-rotation technique

- A deceleration equivalent to Auto-Brake in High mode
- A realistic dry runway with normal rubber contamination
- Idle reversers
- Margins for the system's accuracy.

The WET line provides a landing distance that can be reasonably achieved, under normal operating conditions, on a wet runway. This distance assumes:

- A realistic manual or automatic landing, normal flare and de-rotation technique
- A deceleration equivalent to Auto-Brake in High mode
- A realistic wet runway with normal rubber contamination
- Max reversers
- Margins for the system's accuracy.

Above 500 ft RA

The computation of the DRY and WET lines is based on predicted data, in the frame of the Brake To Vacate achievable operational landing distance check function described in the "**From BTV to ROPS**" box.

Whenever a significant change of conditions occurs after the Brake to Vacate preparation and operational landing distance check (TWR wind change inserted in FMS for appropriate speed managed, RWY condition change), a quick new operational landing distance check is possible with minimal crew workload.

Below 500 ft RA

The computation of the DRY and WET lines is based on measured data, by computing the operational landing distance realistically achievable, in real time.

This landing distance is calculated by taking account of the aircraft weight, ground speed, wind conditions, landing configuration and vertical/horizontal trajectory with respect to the runway threshold.

Note: In Auto-Brake modes other than BTV, the DRY and WET lines are not displayed. On the A380 in BTV mode, the DRY and WET lines can be checked on the Navigation Display (ND)

Above 500 ft RA:

In PLAN mode and in Airport Navigation range, as soon as the landing runway is selected during the BTV preparation, then with BTV mode set

Below 500 ft RA:

In ARC mode and in Airport Navigation range (below 5NM), with BTV mode set.

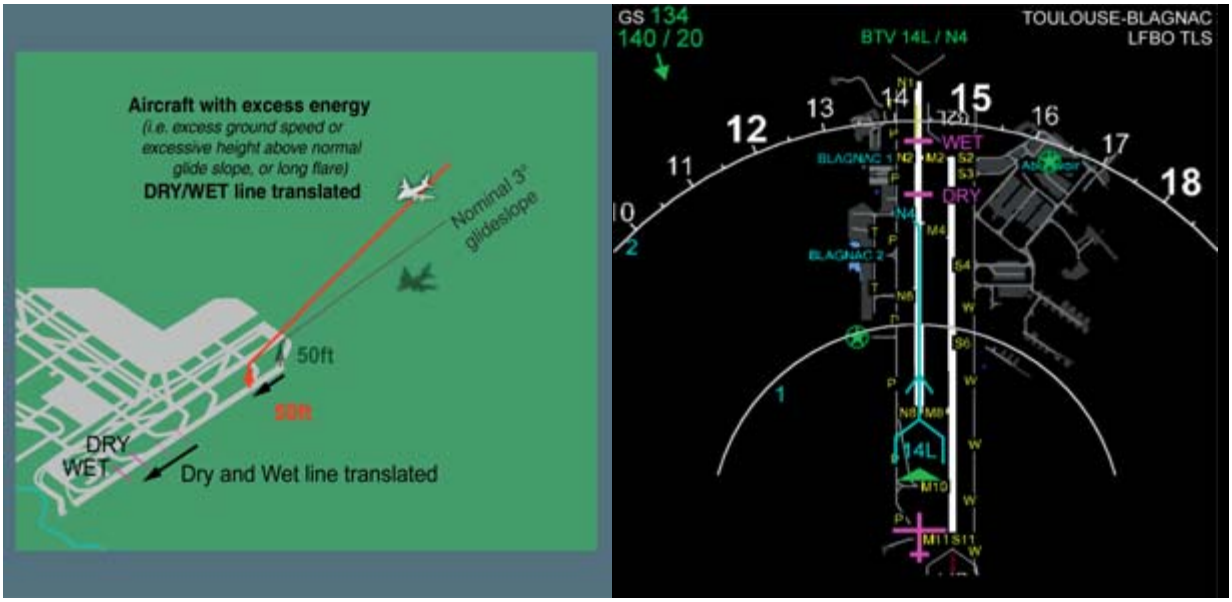

Figure 2: Illustration of DRY and WET lines
Left:impact of excess energy approach at landing (without overrun risk)
Right: example of ND in ARC mode and Airport Navigation range

3.1.2 ROW: The Runway overrun alerts

If the WET line moves beyond the end of the runway, it turns amber on the Airport Navigation Display and a "**IF WET : RWY TOO SHORT**" caution is displayed on the PFD.

Figure 3: Illustration of PFD and ND (ARC mode in Airport Navigation range) in case of "Wet" ROW alert

If the DRY line moves beyond the end of the runway, the DRY and WET lines turn red on the Airport Navigation Display, and a "**RWY TOO SHORT**" warning is displayed on the PFD. In addition, a "RUNWAY TOO SHORT!" repetitive audio callout triggers below 200ft.

Figure 4: Illustration of PFD and ND (ARC mode in Airport Navigation range) in case of "Dry" ROW alert

3.2 The Runway Overrun Protection

From Auto-Brake activation until the aircraft stops, the Runway Overrun Protection (ROP) will:

- Compute and display a stop bar on the Navigation Display
- Automatically increase the braking to maximum braking and trigger appropriate alerts under predicted runway overrun conditions.
  This braking is equivalent to that developed in a rejected take-off by the Auto-Brake in RTO mode, which represents the maximum physical braking capacity of the system.

3.2.1 ROP: The stop bar on the ND

The green stop bar indicates the best possible estimation of the remaining landing roll-out distance, integrating the current aircraft ground speed, deceleration rate and distance to the runway end. It is continuously updated taking account of the actual braking conditions (runway friction and slope, thrust reversers, anti-skid, etc…).

Figure 5: Illustration of ND (ARC mode in Airport Navigation range) in normal condition

3.2.2 ROP: Automatic braking increase and alerts

If the landing is performed despite the ROW warnings, or if the aircraft's deceleration is not sufficient, the ROP stop bar will appear, or move, beyond the end of the runway. In this situation, the path and stop bar turn red on the Airport Navigation Display, and a "**MAX REVERSE**" warning is displayed on the PFD.

Max physical braking is automatically applied (if Auto-Brake or BTV selected).

In addition, a repetitive "MAX REVERSE!" aural alert is triggered if max reversers are not both selected. This message will be repeated until the crew selects both max reversers.

The "**MAX REVERSE**" warning remains on the PFD as long as the stop bar shows a runway overrun condition, whether or not Max Reverse is set.

If the stop bar still shows a runway overrun condition at 80 knots, a "KEEP MAX REVERSE!" audio callout is triggered once, to warn against undue Max Reverse de-selection as recommended in SOP.

Whenever the stop bar comes back inside the runway, and no longer predicts a runway overrun condition, the ROP reverts and allows normal BTV braking operation to resume.

Figure 6: Illustration of PFD and ND (ARC mode in Airport Navigation range) in case of ROP alert

3.3 Synthesis of the Runway Overrun Protection System

	ND (< 500 ft)	PFD (< 500 ft)	Audio (< 200ft)	Actions
ROW (WET)	WET line DRY line	IF WET, RWY TOO SHORT	None	GA decision (crew)
ROW (DRY)	WET line DRY line	RWY TOO SHORT	RWY TOO SHORT !	GA decision (crew)
ROP	RED stop bar	MAX REVERSE	MAX REVERSE ! KEEP MAX REVERSE ! (< 80 KIAS)	Max Braking (Auto) Max REV (crew)

4 Implementation of the ROPS

As outlined earlier, the ROPS combined with the BTV mode allows the operation of all available system functionalities:

- The system is informed of the landing runway selected by the crew during the approach preparation
- Until 500ft RA, the crew may benefit from the display of the "predicted" DRY and WET lines on the ND
- From 500ft RA, the crew will benefit from the display of the "real time" DRY and WET lines
- From 500 ft RA, the crew will benefit from the ROW alerts
- At Auto-Brake activation, the crew will benefit from all ROP functions: STOP bar display on the ND, automatic braking assistance and PFD / audio alerts.

When landing in classic Auto-Brake mode, without the BTV:

- The system is not informed of the selected landing runway until it automatically detects it in short final
- The crew will only benefit from the ROW alerts once the landing runway is identified
- The DRY and WET lines will not be displayed on the ND
- All ROP functions, however, will be available at Auto-brake activation.

The ROW/ROP functions are available:

- For all aircraft landing configurations (weight, CG, slats/flaps configuration, etc.)
- Without any wind or visibility limitations
- For all airports available in the Airport Navigation database.

Thanks to the runway shift function, the system is able to integrate a temporary change of available runway length (NOTAM, Land & Hold Short Operations for instance).

5 Summary and way forward

The Runway Overrun Prevention System proposed by Airbus, through the BTV/ ROPS option on the A380, is a comprehensive tool to:

- Help the crew in the go-around decision making process, in flight
- Assist and warn the crew during the ground phase, on the required actions to reduce the risk of runway overruns, or limit the overrun speed.

The system is expected to be certified, under a new specific EASA performance regulation, by summer 2009 on the A380. It will be available through a software change.

In the near future, the protection offered by the ROPS will be available as well in manual braking mode. This "manual ROPS" is expected to be proposed on the A320 and A330/A340 families by 2011/2012.

The ROPS will be basic on the A350XWB.

The extension of the ROPS capabilities to contaminated runways is currently under study.

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